

Measuring Buildings for CAD Measured Drawings

The Lincoln and Jefferson Memorials

Mark Schara

Since June 1991, HABS has been working on a project, in conjunction with the National Capital Region (NCR) and the Denver Service Center (DSC), to document the Lincoln and Jefferson Memorials in order to produce a "record set" of drawings of the two buildings. These drawings, detailing the existing conditions of the two structures, are to be used as the base drawings for the upcoming restoration of these important buildings.

At an early stage in the development of the project it was determined that, instead of producing traditional HABS ink-on-Mylar drawings, all drawings were to be done on computer, using computer-aided drafting (CAD) techniques. The software chosen was AutoCAD Release 11, the National Park Service (NPS) standard. Although HABS has used CAD on a limited basis in the past (most notably to record the Texas State Capitol), this will be the first HABS project resulting in a complete and extensive set of measured drawings (plans, elevations, sections, details) on CAD. As such, our goals for this project have included developing HABS standards for CAD drawings, as well as developing a methodology for measuring buildings for CAD drawings.

Our experience to date has confirmed numerous advantages for CAD drawings when compared to traditional drawings done by hand. One advantage is that it allows us to work on very large drawings. The main level plan of the Jefferson Memorial, if drawn by hand at a scale of $1/8" = 1'-0"$, would require a sheet at least five-foot-square, an extremely awkward size with which to work. Drawing with CAD, however, allows the user to "zoom" in and out of the image, and thus work on only a small part of the drawing at one time, and at any scale desired. This situation is analogous to a word-processing program, where, at any given time, the user sees and works on only part of one page of a much longer document. And because the CAD image is essentially drawn at full scale, it allows us to contain in a single drawing all of the detail which would typically be drawn on several different sheets at several different scales in a hand-drawn set. Another advantage involves the ability to replicate discreet items with simple "copy" or "array" commands, again, similar to the "copy" command of a word-processing program. Thus, at the Jefferson Memorial it was necessary to actually draw only one exterior column in plan, and then copy it to produce the other 37. In a hand drawing, all 38 columns would have had to be drawn individually. Yet another advantage involves the ability to draw different items in different

"layers," which can subsequently be turned on and off. This allows the user to manipulate both the visual and the plotted images, in terms of what is shown and not shown. Thus, for example, in the plan drawing of the Lincoln Memorial the walls, the door and window openings, the floor joints, the molding edges, and the stairs are each drawn in a separate layer, and any combination of these items can be plotted simply by turning on or off the appropriate layers. Finally, a major advantage of CAD drawings is their ability to be plotted at any scale desired, by means of a simple change in one of the plot command parameters. This dispenses with the necessity of either redrawing by hand or of using photographic reproduction when a drawing at a different scale is needed.

For the Denver Service Center, supervisors of the restoration project, and the National Capital Region, in charge of maintenance of the two buildings, having CAD drawing files of the Lincoln and Jefferson Memorials will prove to be invaluable. A significant advantage of magnetic media is the ease with which it can be copied and dispersed, and already both the DSC and several of its architectural and engineering contractors are using copies of the HABS CAD files as the base drawings for their restoration work. In addition, AutoCAD allows written data to be entered and keyed into specific entities in its CAD files. For example, specific information from various surveys as well as records of maintenance can be entered and listed directly in the appropriate drawing. For the NCR, the CAD files will provide a useful database that can be easily updated when changes are made to the buildings, rather than using drawings which will have to be laboriously redrawn to remain current.

Traditional HABS drawings are drawn in ink on Mylar, at a pre-determined scale. And in fact, one final result of this project is to be a complete set of $1/8" = 1'-0"$ scale drawings plotted on Mylar and then deposited at the Library of Congress. As noted above, however, CAD



HABS architect Mark Schara (left) and HAER photographer Jet Lowe are captured in an image taken by the photogrammetric camera mounted at the end of a photo boom at the top of the Lincoln Memorial scaffolding. The empty frame provides four coordinates of known separation, used to provide scale and orientation during the digitizing process. The resulting drawing is shown at right.

Photo by Jet Lowe, 1992, HABS/HAER.

drawings are essentially drawn at full scale and then plotted at whatever scale is desired. The need to measure these buildings in order to accommodate full-scale drawing accuracy has remained a challenge throughout the course of the project. Whereas a 1/2" discrepancy would be indiscernibly small on a 1/8" or 1/4" scale drawing, it remains 1/2" on a full-scale CAD drawing. In addition, the AutoCAD software allows an incredible accuracy in drawing, to 1/64" in English units or to eight decimal points of an inch in decimal units. This accuracy is well beyond our ability to achieve in measuring (as, in fact, it is well beyond the ability of the construction industry to achieve in building).

Thus it became apparent to us at the beginning of this project that a great deal of accuracy would be required in our measurements, more so than for a traditional HABS project. We decided to measure to the nearest 1/8" (this was the smallest division on some of our measuring tapes) for most aspects of our drawings, and to the nearest 1/16" for certain details (such as moldings). This need for accuracy was compounded by the enormous size of these two buildings, allowing for the greater potential for discrepancies and inhibiting our abilities to take long strings of dimensions because of sag in the tapes. We soon abandoned the use of cloth (fiberglass) measuring tapes for most situations because of their tendency to stretch when pulled over long distances. We determined metal tapes to be more dimensionally stable, if occasionally less flexible.

There have been other challenges associated with measuring these buildings. As both buildings are to remain open to the public during their restoration, we have had to work around the large number of daily visitors each receives. The sizes of the buildings precluded their being completely wrapped in scaffolding, because of the expense. Instead, four moveable scaffolding towers were erected at the Lincoln Memorial and two at the Jefferson Memorial, each spanning one bay. Our dimensioning in the areas accessed by the towers had to be incremental, rather than using the continuous strings favored by HABS for accuracy. It also had to be timely and complete, as the towers only occupied any given position once. While the scaffolding towers provided us with invaluable access to the building surfaces for measuring (as well as providing access for various survey teams and

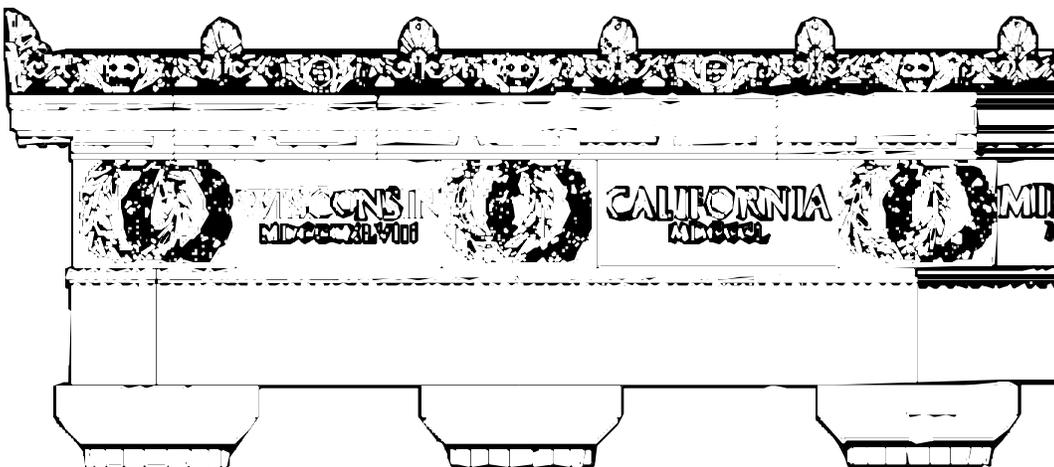
future restoration work), they were too close to the building for the photogrammetric photography which we were undertaking. This problem was solved by the use of several 11'-long custom-built booms, designed by DSC in conjunction with HABS, which were mounted to the scaffolding. By mounting our camera on the end of the boom, swinging it out into space, and positioning it so that it faced back toward the building, we were able to get the images we needed from the appropriate distances.

As noted, photogrammetry has been an integral part of this project. We are using two Linhof Metrika cameras, unique in the United States, in conjunction with PhotoCAD, a photogrammetric software which works as an add-on to AutoCAD. This software allows us to digitize photogrammetric images, producing AutoCAD drawing files. We have used the two-dimensional version of PhotoCAD extensively, documenting, for example, the carved ornament at the entablature and the attic parapet of the Lincoln Memorial as well as the Ionic capitals of the Jefferson Memorial. Typically, this kind of detail would be extremely difficult, if not virtually impossible, to measure and draw by hand, especially at the level of accuracy we are obtaining with photogrammetry. The three-dimensional version of PhotoCAD has proven useful in the basement of the Lincoln Memorial, where the use of scaffolding was determined to be prohibitively expensive. It has enabled us to document the structural framing at the underside of the slab, 40' above grade, by the use of photogrammetric images taken from below. (A more extensive description of this photogrammetric process can be found in the article, "Charleston Photogrammetry," elsewhere in this issue.)

As with all new technologies, our use of CAD-photogrammetry has not been trouble-free. In addition to the usual learning curve, there have been simple problems concerning access and lighting, as well as occasional mechanical glitches with our equipment. More problematic, we have discovered that the resulting drawing files tend to be extremely large because of the amount of detail contained, thus taxing both AutoCAD's capabilities as well as the memory available in our computer system. In fact, at a point approximately two-thirds of the way through the project, we have had to significantly upgrade our computer system in order to handle these

drawing files. Nonetheless, as we work toward resolving these issues, it seems apparent that both CAD and CAD-photogrammetry will become increasingly more useful, and thus increasingly used, as tools to document our Nation's historic resources.

Mark Schara, an architect with HABS, is supervisor of the Lincoln and Jefferson Memorials documentation project. He has previous work experience with HABS in Alaska and in Washington, DC, as well as in the private sector.



Lincoln Memorial cornice. Delineated by Jose Raul Vazquez, Mellonee Rheams, Dana Lockett, and Mark Schara, 1992, HABS/HAER.